16.20 **Handed Out: Lecture 12**
Due: Lecture 16

HOME ASSIGNMENT #3

Warm-Up Exercises

Let's explore the use of Mohr's circle for strains in the case of plane stress. Use geometrical arguments/considerations to:

1. Show that the transformation of an arbitrary state of in-plane strain (ε_{11}, ε_{22}, ε_{12}) to another in-plane system ($\tilde{\varepsilon}_{11}$, $\tilde{\varepsilon}_{22}$, $\tilde{\varepsilon}_{12}$) yields the three equations represented by:

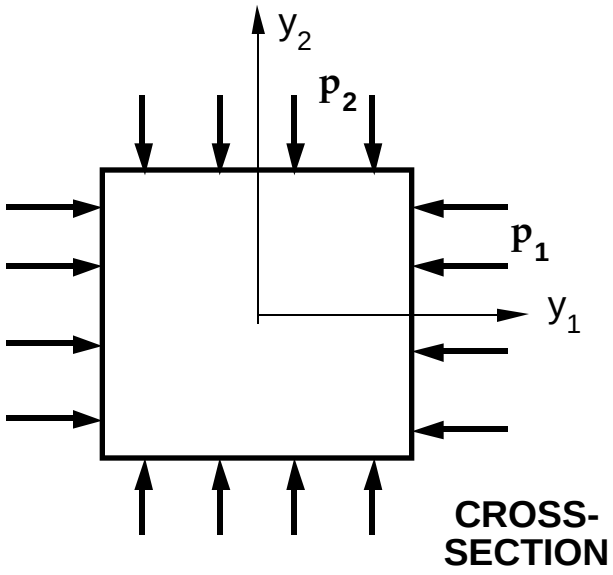
$$\tilde{\varepsilon}_{\alpha\beta} = \ell_{\tilde{\alpha}\sigma}\, \ell_{\tilde{\beta}\lambda}\, \varepsilon_{\sigma\lambda}$$

2. Look at the circle diameter. The circle diameter is some combination of the strains that is invariant. Determine what this is (in terms of $\varepsilon_{\alpha\beta}$ and the transformation angle θ).

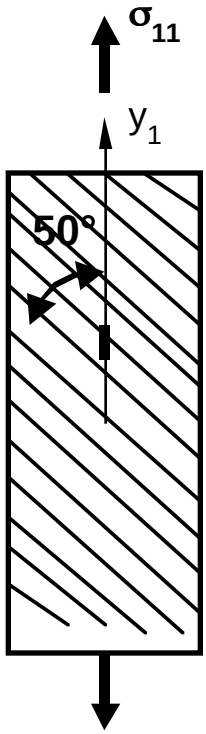
3. Does the combination of strains that coincides to the circle diameter have any physical significance? If so, what is it; if not, is there another geometric item with physical significance?

Practice Problems

4. A 2-meter long aluminum bar has a square cross-section (35 cm to a side) and is subjected to uniform side pressures of p_1 and p_2. The modulus of aluminum is 70.8 GPa and the Poisson's ratio is 0.3. Determine the stress and strain states using both the plane stress and plane strain assumptions for various ratios and values of the two pressures. What is the applicability of the two models?



5. A unidirectional graphite/epoxy specimen is loaded by a uniaxial stress of 200 MPa along the y_1-axis. The fibers of the composite are at an angle of 50° to this axis. A strain gage is placed to measure strain in the direction of the applied stress. The composite has the following properties as referenced to the fiber direction:



$$E_L = 143 \text{ GPa}$$
$$E_T = 9.8 \text{ GPa}$$
$$G_{LT} = 6.0 \text{ GPa}$$
$$\nu_{LT} = 0.28$$

   (a) Determine the stresses along and perpendicular to the fibers.

   (b) Determine the strains along and perpendicular to the fibers.

   (c) Determine the strains along and perpendicular to the y_1-axis.

Application Tasks

6. You are asked to determine the properties of a new type of unidirectional graphite/epoxy material.

   (a) First indicate which independent material properties need to be determined to define the plane stress elasticity tensor.

   (b) In order to determine these properties, two sets of tests are ordered to be done on some available material. In Test A, an extensional load corresponding to a stress of 450 MPa is placed along the fiber direction with strain read from gages placed along and perpendicular to the applied load. In Test B, an extensional load corresponding to a stress of 200 MPa is oriented at 35° to the fiber direction. Strain gages are placed parallel and perpendicular to the fiber direction as well as along the loading direction.

The tests results are as follows. For Test A:

Gage 1 = 2600 μstrain
Gage 2 = - 850 μstrain

For Test B:

Gage 1 = 11900 μstrain
Gage 2 = 650 μstrain
Gage 3 = 10100 μstrain

Using this data, determine the properties that you listed in part (a).

(c) Are there more strain gages than needed in order to determine the properties? If so, can we arbitrarily eliminate some? Which and why?